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WATER QUALITY STUDIES. BONNEVILLE RESERVOIR

Public Health Service
Cincinnati, Ohio

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WATER QUALITY STUDIES - BONNEVILLE RESERVOIR

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FEDERAL SECURITY AGENCY
Public Health Service
Environmental Health Service
Cincinnati, Ohio

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SYLLABUS

The study of the Bonneville Reservoir was carried out as a part of the Columbia River Studies project of the Public Health Service. Two main objectives of the overall program are (1) to determine the effects of impoundments upon stream water quality and (2) to determine the effects of radioactive materials upon the normal chemical, physical, and biological parameters of stream water quality. Data from the Bonneville Area are intended to supplement the information from the upstream area and to assist in predicting the effect of the impoundments.

The Bonneville Reservoir is a "run-of-the-river" impoundment, developed primarily for power purposes and with little or no provision for flood storage. The McNary Reservoir area, located some 150 to 200 miles above Bonneville Dam and developed for the same purpose, is being studied prior to operation of the impoundment.

The studies in the Bonneville Reservoir involved, essentially, the collection of samples of water, aquatic organisms, and bottom muds and, from them, the determination of existing physical, chemical, bacteriological, biological, and radiological conditions.

The results of this study show that:

1. The physical and chemical conditions were fairly uniform throughout the reservoir and were well within the limits expected to support a good mixed aquatic biota. The only exceptions were the occurrence of considerably higher values for ammonia nitrogen at several of the sampling points and a slight temperature increase from the upper to the lower end of the pool.
2. There was little or no build-up of plankton within the reservoir during the period of the study. The forms present were quite similar to those found in unimpounded portions of the Columbia

River and occurred in the same relative proportions. There was a possible slight increase in green and blue-green algae, and in protozoans.

3. The physical nature of the pool bottom was such as to discourage the establishment of bottom animals. Most of the river bed seemed to be covered with a layer of fairly coarse to fine sand, considerable debris, and some mud deposits. The pool areas therefore appeared to be much less productive of bottom organisms than were unimpounded areas. The organisms present were also of a less desirable type from the standpoint of serving as fish food.

4. Juveniles of shiners, squawfish, and chiselmouth were the predominant species, according to the fish collections. The presence of a few young bass and crappie indicate at least some successful spawning of spiny-rayed species within the pool area. Juvenile salmon are probably abundant during certain seasons of the year but would not be expected during the period of this study.

5. There is a uniform mixing of the radioactive elements across the width of the reservoir and a gradual decrease of radioactivity between the upper and lower ends of the impoundment.

6. Appreciable quantities of radioactivity were present in all the types of aquatic organisms examined throughout the pool. However, the order of magnitude was such that it would be expected to have little or no effect on these organisms, or on their use.

Due to rough water the collection of adult fish was very limited. Several sturgeon and one squawfish were caught by gill nets. There is some

commercial fishing in the area, mostly for blueback and chinook salmon, and to some extent for sturgeon. A few parts are considered excellent for sport fishing, mostly for steelhead trout, but catches of chinook salmon, resident trout, sturgeon, and squawfish have also been reported from the pool area and the mouths of tributary streams.

GENERAL INFORMATION

The main purpose of the Bonneville Reservoir Study was to obtain data on the limnological and radiological status of a Columbia River impoundment which had been in operation for several years. It was expected that the survey would yield data useful in predicting the future effect of McNary Reservoir (a similar type of impoundment expected to be placed into operation in 1953 and located approximately 150 miles upstream from Bonneville Dam) on stream water quality. The data obtained were also expected to be useful to other agencies participating in or interested in this study.

PARTICIPATING AGENCIES

Several Federal agencies assisted in the conduct of the survey, each one having certain interests in the results.

The U. S. Corps of Engineers is interested in the chemical quality of the water as it might affect the turbines and other machinery at the Bonneville Dam Power Plant. The Corps is also interested in overall limnological conditions, particularly from the standpoint of their effect on the passage of fish over the dam and through the impoundment.

The U. S. Fish and Wildlife Service is interested primarily in limnological conditions and possible effects on fish management or rehabilitation programs. The State Health Authorities are interested in sanitary water quality as affected by municipal or industrial waste discharges. The Public Health Service Northwest Drainage Basins Office is interested from the standpoint of their overall responsibilities in the pollution abatement and control programs in the Pacific Northwest.

GENERAL PLAN OF OPERATION

This survey was conducted during the period August 18 through 29.

1952. It was felt that with the limited time available it was best to do the study during low water stages and during a period of maximum water temperatures. The greatest concentrations of chemical constituents and highest biological activity would normally be expected under such conditions.

Six sampling ranges were established within the reservoir area. Each range was designated by a mileage index number, which gives the distance, in miles, from a fixed reference point established by the U. S. Corps of Engineers at the mouth of the Columbia River. The use of this system permits a tie-in with the Public Health Service studies made in the Priest Rapids - Paterson section, as well as with studies made by various agencies in other sections of the Columbia River Basin. Sampling points were located from the standpoint of obtaining information on the impoundment as a whole. The limited time available for the study precluded the collection of information from individual sources of pollution and major tributaries. The area covered by the study and the location of sampling points are shown in figure 1.

The sampling ranges established for the studies were as follows:

1. C-191: One mile above The Dalles, Oregon; set up as a control station. It is actually within the backwater area but has a much more rapid flow and conditions here would closely approximate actual stream conditions. It is also above any suspected source of pollution entering the reservoir directly.

2. C-182: Immediately above Lyle Ferry, but well below The Dalles, Oregon.

3. C-167: One mile below the mouth of the White Salmon River. This range is also below the Hood River and the towns of Hood River, Oregon, and White Salmon and Bingen, Washington.

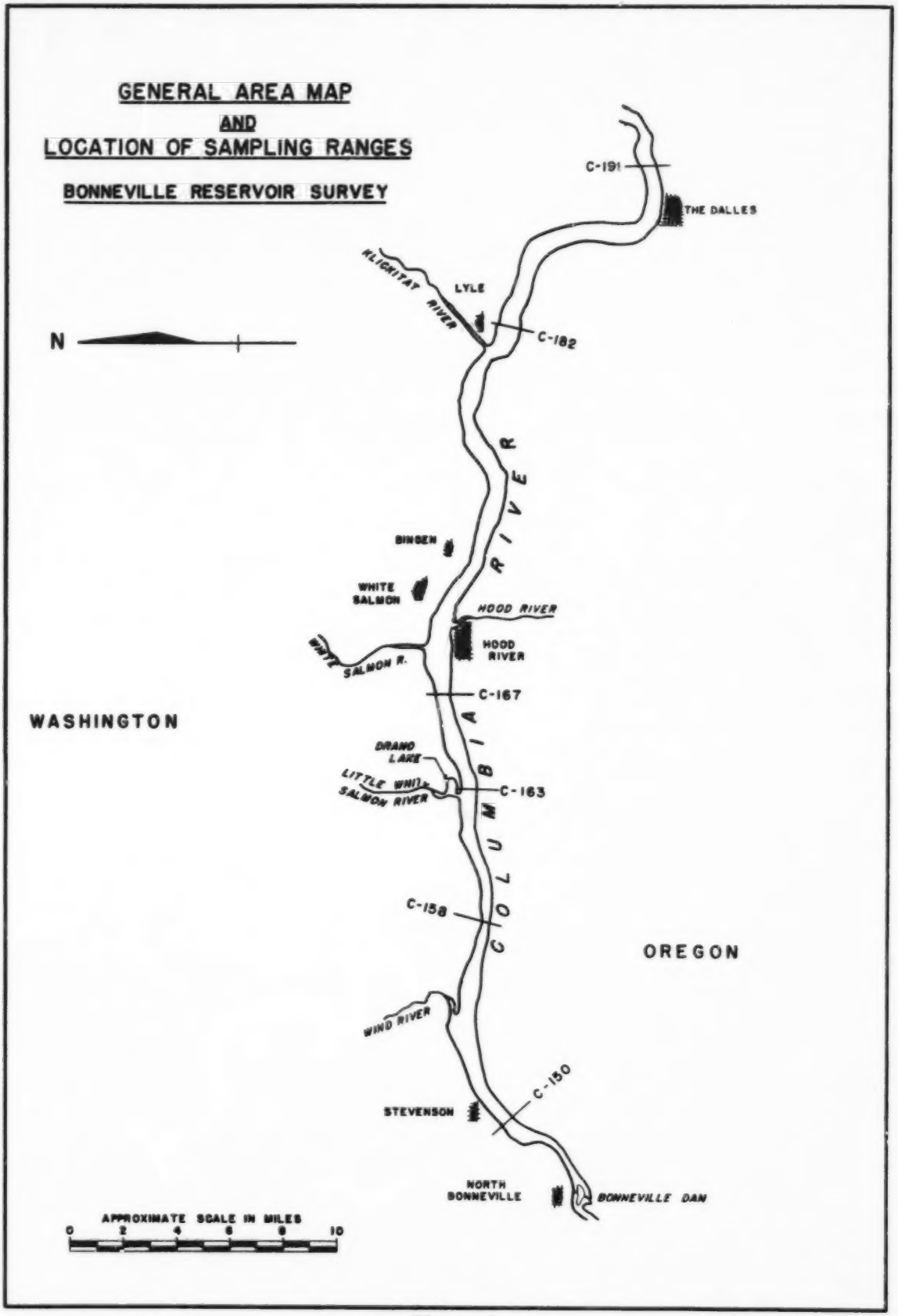
GENERAL AREA MAP
AND
LOCATION OF SAMPLING RANGES
BONNEVILLE RESERVOIR SURVEY
N
C-191
THE DALLES
KLICKITAT RIVER
LYLE
C-182
COLUMBIA RIVER
BINGEN
WHITE SALMON
HOOD RIVER
HOOD RIVER
WHITE SALMON R.
C-167
WASHINGTON
DRANO LAKE
LITTLE WHITE SALMON RIVER
C-163
C-158
OREGON
WIND RIVER
C-150
STEVENSON
NORTH BONNEVILLE
BONNEVILLE DAM
APPROXIMATE SCALE IN MILES
0 2 4 6 8 10

Figure 1

5. C-158: Near Collins Point Light. Principal sampling point only.

6. C-190: One mile below Stevenson, Washington. This was the furthest downstream point which was readily accessible for sampling.

Space for a field laboratory was made available at the U. S. Fish and Wildlife Service at their Little Hulte salmon hatchery, located at the upper extremity of Drano Lake. Single counting and dissection operations were performed there. Other more complex laboratory work or chemical analyses and radiological examinations were made in the Public Health Service Laboratory at Richland, Washington. Radio transportation services were made by the Oregon State Sanitary Authority in Portland, Oregon.

Personnel assigned to the field work included one chemist and one physicist from the Columbia River Studies group and two technicians from the PHS Northwest Radiological Health Office. Field assistance from the Columbia River Studies group collected data at the sampling stations and assisted at the site of collection for return to the permanent laboratory. Personnel from the Oregon State Sanitary Authority transported the transplanted samples from the site of collection to Drano Lake.

It was originally planned to collect data from the stations five miles upstream and downstream (Nos. 4 and 5) employing a 20 ft. boat with outboard motors (10 and 25 horsepower). This did not prove feasible, because at low water one was not afloat during a large portion of the survey period due to hazardous rapids above Drano Lake. Consequently a commercial fishing boat was rented for at

least a part of the sampling.

DESCRIPTION OF THE RESERVOIR

The Bonneville Reservoir is a body of water approximately 50 miles long, one-half to one and one-half miles wide and generally varying from 30 to 100 feet in depth, created by the impoundment of the Columbia River by Bonneville Dam. It extends from the Dam to a point just above The Dalles, Oregon. This dam, a so-called "run-of-the-river-dam", is located approximately 40 river miles east of Portland, Oregon and 140 river miles above the mouth of the stream. Constructed mainly for the production of hydro-electric power, it has several built in features, such as fish ramps for the passage of migratory fish and navigation locks for ship traffic. The structure was built by the U. S. Corps of Engineers and placed in operation in 1938.

STREAM FLOWS

River flows were quite uniform during the survey and the reservoir was at normal pool elevation, 72 feet above mean sea level, throughout the period of study. Average daily flows at The Dalles varied from 119,000 to 132,000 c.f.s., with an overall average of 125,300 c.f.s. The flows were somewhat above minimum low flows which may be reached later in the fall or winter, but well below the average annual spring flood flow of 385,000 c.f.s. Pool elevations may reach a maximum of 82.5 feet above mean sea level during the high run-off periods. Maximum flows normally occur in June and the minimum in December.

At The Dalles the maximum average daily flow of record is 1,160,000 c.f.s., and occurred in June of 1894. The minimum average daily flow, recorded on several occasions, has been in the neighborhood of 40,000 c.f.s.

Surface velocities, during the period of the survey, appeared to be much higher at the control section (Range C-191) than at other sections.

The estimated velocity was about 3 feet per second, as against ½ foot per second or less at ranges within the reservoir.

SURVEY PROCEDURES

Samples of water, aquatic organisms, and bottom muds were collected and examined for the determination of physical, chemical, bacteriological, biological, and radiological conditions. The results are discussed in a later section of the report. The procedures used for collection and examination of these samples are described briefly in this section.

Chemical and physical determinations on individual samples included those for turbidity, temperature, dissolved oxygen, alkalinity, pH, free carbon dioxide, ammonia, nitrites, phosphates, and specific conductivity. Analyses for calcium, magnesium, iron, manganese, zinc, copper, sulfates, nitrates and total solids were made on composite, cross-sectional surface samples taken at some of these ranges. Biological collections included plankton, filamentous algae, bottom organisms, and fish. Bacteriological samples were obtained at stations designated by the Oregon State Sanitary Authority. Water, plankton, algae, bottom organisms, fish (juvenile and adult), and bottom muds were taken for determination of gross beta activity densities. Alpha activities were also determined on bottom mud samples.

COLLECTION OF SAMPLES

The collection of various types of samples was in accordance with procedures used or adapted for the studies in the Priest Rapids - Paterson section of the Columbia River.

Water

Samples of water for field determination of temperature, turbidity, dissolved oxygen, alkalinity, pH, and free carbon dioxide were taken with a 3-liter Kemmerer sampler, at the surface and near the bottom. Collections

were made at quarter points across all of the ranges. For the remaining chemical and physical examinations 1,000-milliliter surface and depth samples were obtained at the quarter points on Ranges C-191, C-167, and C-150. Five-gallon composite surface samples were taken at these same three ranges for determination of the mineral constituents.

Two sets of surface samples for bacteriological examinations were taken only near the two shores and at the quarter points on Ranges C-182 and C-167. For the determination of radioactivity densities, 1,000-milliliter surface samples were obtained from Ranges C-191, C-167, and C-150.

Aquatic Organisms

Composite water samples from the surface and near the bottom were obtained at all ranges for plankton count and weight determinations. Tows were also made with a standard silk bolting cloth net (number 20) at each range to determine the presence and relative abundance of some of the larger plankton organisms (zooplankton).

Quantitative bottom organism samples were taken with an Ekman dredge, where possible, at each range. Other collections were made at various shore points by picking from rocks and by seining.

Juvenile fish collections were made at shore points at each of the various locations by seining with a 10-foot, 1/4-inch-mesh minnow seine. Adult fish collections were taken with gill nets, but only a few specimens were caught. Much of the information on fish was obtained by observations at the Bonneville Dam fish ladders and through conversations with local sport fishermen, commercial fishermen, and others.

Bottom Muds

A limited number of bottom mud samples were collected with the Ekman

Dredge. Portions weighing about 20 grams (after oven-drying) were used to determine the radioactivity.

LABORATORY METHODS

The laboratory methods used for many of the routine examinations were taken from various standard sources. Other procedures were those developed for the main portion of the Columbia River Studies, in the Priest Rapids - Paterson Section.

Chemical and Physical Examinations

Analytical techniques for most of the chemical and physical examinations were those given in "Standard Methods for the Examination of Water and Sewage", 9th Edition, American Public Health Association, with some modifications to fit the field conditions.

Surface water temperatures were read from a regular Centigrade thermometer, while depth temperatures were taken with a Negretti-Zambra reversing thermometer. Surface turbidity readings were read with a USGS Standard Water Turbidity Scale. Analyses for dissolved oxygen, free CO_2, pH, and alkalinity were made in the field with a portable chemical kit. All other tests were done at the Richland laboratory. The methods for determining copper and zinc were taken from "Colorimetric Determination of Traces of Metals", by E. B. Sandell (Interscience Publishers, Inc., 1950). Specific conductances were determined with an Industrial Instrument Company Solu Bridge, Model RC-16-B.

Bacteriological Examinations

As already stated, examinations for the bacteriological samples were made at the laboratories of the Oregon State Sanitary Authority at Portland, Oregon. Laboratory methods used were those given in "Standard Methods", 10

Biological Examinations.

Procedures for the collection and examination of aquatic organisms generally followed those given in "Limnological Methods", by P. S. Welch. (The Blakiston Company, 1948).

Two-liter water samples for count and 10 liter samples for weight were centrifuged in a Foerst Centrifuge, the organisms removed, and preserved for plankton counts and weights. Later, in the Richland laboratory the organisms were identified and counts made in a Sedgewick-Rafter counting cell. Weights were determined after drying at 60°C for 24 hours. The organic content was found by ashing in a muffle furnace at 600°C for 30 minutes and reweighing.

Bottom organism samples were sorted, identified to order, counted, and weighed. Juvenile fish samples were sorted and data on relative abundance of species recorded. For adult fish the data included approximate length, weight, sex, and species of each specimen.

Radiological Examinations

The radiological examinations included the determination of gross beta activity densities on samples of water, plankton, filamentous algae, bottom organisms, fish, and bottom muds. Alpha activity was determined on the bottom muds. Field collections were made as previously discussed for these various types of samples.

Water samples were prepared for counting by acidifying and evaporating nearly to dryness in beakers. The sample was then transferred to a small stainless steel dish, 1 inch in diameter, for complete evaporation. After final drying, the dish was muffled for 1 minute in a 600°C oven and the contents counted. Aquatic organisms were prepared for radioactivity counting by digesting in nitric acid, evaporating, ashing, and plating on the

stainless steel dish.

Radioactivity counts for bottom muds were made on the residue obtained by the extraction of the radioactive elements from the mud particles. This was deemed necessary in view of the low count per gram of dry weight and the large correction factors resulting from the use of a large and dense sample.

All beta counting was done in Geiger-Mueller, end-window tube counters. Internal flow counters were used for alpha determination.

It was necessary to obtain correction factors for decay, self-absorption, and air and mica-window absorption. These factors were determined on a few representative samples of each of the types examined and then applied to individual counts to give absolute values in terms of microcuries per milliliter or per gram.

DISCUSSION OF RESULTS

The total number of samples collected and analyses made are given in table 1. The results of the laboratory examinations are discussed below.

Table 1 - SUMMARY OF SAMPLING AND LABORATORY LOAD

Examination	No. Samples	Determinations.
Bacteriological	20	20*
Chemical and Physical		
Routine	115	760
Mineral Analyses	9	81
Biological		
Bottom Organisms	11	11
Plankton	46	46
Radiological		
Water	27	27
Biological Specimens	184	184
Bottom Muds	8	16
Decay Studies	17	17

* Examinations made by Oregon State Sanitary Authority Laboratories.

BACTERIOLOGICAL EXAMINATIONS

Though only two sets of surface samples were collected at each range there is an indication that the domestic pollution, as shown by the coliform results, is principally on the Oregon shore. The highest MPN value, 700 per 100 ml., occurred about 7 miles below The Dalles, Oregon, at Range C-132, and in the relatively shallow, quiet water 2 miles below the city of Hood River, near the south shore of the Columbia River. It should be noted that low values were found on the Oregon side as well as elsewhere on August 19, but there is no apparent explanation for such values, especially in view of the strong upstream winds occurring on that particular day. The results of

the bacteriological analyses are presented in table 2.

Table 2 - RESULTS OF BACTERIOLOGICAL ANALYSES

Distance from North Shore	Date (1952)	M.P.N. per 100 ml.	
		Range C-182	Range C-167
100'	8/19	240	45
	8/27	240	23
1/4	8/19	230	45
	8/27	62	23
1/2	8/19	45	60
	8/27	62	23
3/4	8/19	45	230
	8/27	700	700
S. Shore (100')	8/19	60	
	8/27	62	700

CHEMICAL AND PHYSICAL EXAMINATIONS

There was a slight variation in turbidity readings, values of from 10 to 20 p.p.m. being observed. Similar readings were obtained at all ranges but probably from different causes. From the difference in color observed, it would appear that the slight turbidity at the control section, Range C-191, was caused by suspended silt while that at other ranges was caused by plankton forms.

Water temperature readings were approximately the same for surface and depth samples at all ranges, and showed no thermal stratification anywhere within the pool. Average temperatures were slightly higher at all ranges below The Dalles, thus indicating a slight warm-up within the pool.

Dissolved oxygen values were fairly uniform and consistently high at each range, approaching saturation in all cases. Results obtained from

samples taken in deep water near the bottom were only very slightly below those at the surface, indicating a thorough mixing of the water and little oxygen demand from bottom deposits. Average values were slightly less at the lower ranges.

The average values for ammonia nitrogen at all ranges were much higher than had been found in the Priest Rapids - Paterson section of the Columbia River. Data ranged from a low of 0.05 p.p.m. to a high of 1.60 p.p.m. The highest results were found below Hood River on the Oregon side, and below Stevenson on the Washington side. Average values for nitrate nitrogen ranges from 0.02 to 0.11 p.p.m., the higher figures being found near Stevenson. No nitrite nitrogen was detected in any of the samples.

Values for specific conductance were generally quite low on all samples, averaging about 190 micromhos per centimeter at all ranges.

Data for pH and alkalinity were fairly uniform at all ranges, pH varying from 8.3 to 8.6 and methyl orange alkalinity from 68 to 72 p.p.m. Phenolphthalein alkalinity values from 3 to 10 p.p.m. were found, with no noticeable variation between ranges. The values for pH and phenolphthalein alkalinity were somewhat higher than those found in the Priest Rapids - Paterson section of the Columbic River. No free CO_2 or mineral acidity was found in any of the areas sampled.

The findings on the mineral analyses of water were comparable and uniform at all ranges. Average values were: 19 p.p.m. for calcium, 6.0 p.p.m. for magnesium, 0.30 p.p.m. for iron, and 15 p.p.m. for sulfates. Traces of other metals were also found to be present, with average concentrations of 0.02 p.p.m. for manganese, 0.003 p.p.m. for zinc, and 0.004 p.p.m. for copper. Phosphate values were fairly uniform throughout the pool, averaging 0.05 to 0.06 p.p.m.

As a whole, the physical and chemical conditions throughout the reservoir were reasonably uniform and well within limits generally considered favorable for the support of a good mixed aquatic biota. The only noticeable difference within the pool itself were the considerably higher values for ammonia nitrogen obtained at several points, and a possible slight temperature increase from upper to lower sections of the pool.

The only significant differences between conditions in the pool and those in the Priest Rapids - Paterson section of the river were, in addition to increased ammonia nitrogen and iron values, a somewhat higher pH and an increase in phenolphthalein alkalinity. It is not believed these differences are due to the impoundment but, rather, to a build-up of these constituents in the river between Paterson and the headwaters of the Bonneville pool.

The above data indicate that little change in water quality characteristics occur in a "run-of-the-river" impoundment, such as Bonneville Reservoir.

The results of the chemical, physical, and mineral examinations are given in tables 3 and 4.

LIMNOLOGICAL EXAMINATIONS

As has already been stated, the chemical and physical conditions in the reservoir are well within the limits generally considered favorable for supporting a good mixed aquatic biota.

Plankton

The variation in plankton between samples taken at the same range was as great as or greater than the difference between ranges. Thus, little change in numbers, weight, or types of organisms was found between ranges.

Table 3 - SUMMARY OF ANALYTICAL RESULTS ON RIVER WATER SAMPLES.

Sampling Range	Distance from North Shore	Date (1952)	Turbidity ppm	Temp. °C.	D.O. ppm	NH_3 ppm	NO_2 ppm	PO_4 ppm	Spec. Cond. Mmhos per cm.	Alkalinity ppm		pH
										M.O.	Phen.	
C-191	1/4 (Surface)	8/20	14	19.0	12.4	0.30	0	0.07	200	72	5	8.4
		8/25	19	19.0	12.3	0.06	0	0.07	190	70	9	8.6
		8/27	13	19.0	11.7	0.32	0	0.01	180	70	7	8.4
	1/4 (70' Depth)	8/25	-	19.0	11.6	-	-	-	-	70	10	8.5
	1/2 (Surface)	8/20	14	19.0	12.4	0.72	0	0.07	200	72	5	8.4
		8/25	-	19.0	11.5	0.14	0	0.09	190	71	10	8.5
		8/27	12	19.0	11.7	0.38	0	0.01	180	71	8	8.4
	1/2 (60' Depth)	8/25	-	19.0	11.6	-	-	-	-	70	9	8.5
	3/4 (Surface)	8/20	14	19.0	12.3	0.64	0	0.07	200	72	7	8.4
		8/25	-	19.0	11.5	0.16	0	0.06	190	69	10	8.5
		8/27	12	19.0	11.7	0.28	0	0.03	180	71	8	8.4

Note: From NO_2 = 0 for all samples taken throughout survey.

Table 1 - Summary of analytical results on river water samples (continued)

Sampling Point	Date and time of the day Hours	Area (1/20)	Tidal flow m/s	Temp °C	Oxygen ppm	BO_5 ppm	CO_2 ppm	SO_4 ppm	Space Used ... cas (ml. ca.	Alkalinity ppm		pH
										M.O.	Thym.	
Creek (Left)	1/2 (Low Water)	8/26		19.0	11.7	-				58	7	8.5
Lake	1/2 (Surface)	8/29	30	20.0	10.1	-	-			74	8	8.4
		8/26	25	20.0	11.0	-	-			78	10	8.5
		8/27	-	19.0	10.0	-	-	-	-	70	8	8.4
	1/2 (Mid Depth)	8/26	-	20.0	11.0	-	-	-	-	69	10	8.5
	1/2 (Surface)	8/29	20	20.0	10.2	-	-	-	-	69	6	8.4
		8/26	15	20.0	11.0	-	-		-	70	9	8.5
		8/27		19.0	10.0	-	-	-	-	70	7	8.4
	1/2 (Mid Depth)	8/26		20.0	11.0			-	-	70	8	8.5

Table 3 - SUMMARY OF ANALYTICAL RESULTS ON RIVER WATER SAMPLES (Continued)

Sampling Range	Distance From North Shore	Date (1952)	Turbidity ppm	Temp. °C	D.O. ppm	NH_3 ppm	NO_2 ppm	PO_4 ppm	Spec. Cond. mhos per cm.	Alkalinity ppm		pH
										M.O.	Phen.	
C-162	1/4	8/19	20	20.0	10.4	-		-		72	6	8.4
(Cont.)	(Surface)	8/24	15	20.0	12.8				-	70	8	8.5
		8/27		19.9	10.8	-	-	-	-	70	7	8.4
	3/4 (15' Depth)	8/24		20.0	10.8	-	-	-	-	71	9	8.5
C-167	1/4	8/20	17	19.5	9.9	0.32	0	0.04	200	68	2	8.3
	(Surface)	8/22	17	19.5	11.8	-	-	-	-	71	7	8.4
		8/25	20	20.0	10.5	0.08	0	0.06	190	68	8	8.5
		8/27	11	19.5	10.8	0.24	0	0.02	180	70	9	8.5
	1/4 (90' Depth)	8/20	-	19.5	9.8	0.08	0	0.10	200	67	3	8.4
		8/22	-	-	11.7	-	-	-	-	70	7	8.4
		8/25	-	20.0	10.5	0.10	0	0.03	190	69	9	8.6
		8/27	-	19.5	10.8	0.06	0	0.04	180	68	8	8.4

Table 3 - SUMMARY OF ANALYTICAL RESULTS ON RIVER WATER SAMPLES (Continued)

Sampling Range	Distance from North Shore	Date (1952)	Turbidity ppm	Temp. °C.	D.O. ppm	NH_3 ppm	NO_2 ppm	PO_4 ppm	Spec. Cond. mmhos per cm	Alkalinity ppm		pH
										M.O.	Phen.	
0-167	1/2	8/20	17	19.5	9.8	0.44	0	0.06	200	68	3	8.4
(Cont.)	(Surface)	8/22	17	19.5	11.9	-	-	-	-	70	8	8.4
		8/25	20	20.0	10.6	0.10	0	0.04	190	69	9	8.6
		8/27	10	19.5	10.7	0.30	0	0.03	170	69	8	8.5
	1/2 (60' Depth)	8/20	-	-	9.9	0.80	0	0.06	200	66	2	8.3
		8/22	-	-	12.0	-	-	-	-	71	8	8.4
		8/25	-	-	10.5	0.20	0	0.04	190	68	8	8.5
		8/27	-	19.5	10.6	0.72	0	0.07	170	68	6	8.4
	3/4 (Surface)	8/20	17	19.5	10.0	0.52	0	0.03	200	67	3	8.4
		8/22	17	19.5	11.5	-	-	-	-	70	8	8.4
		8/25	20	19.5	10.4	1.60	0	0.20	190	66	9	8.5
		8/27	11	19.5	10.6	1.60	0	0.09	170	68	6	8.4
	3/4 (30' Depth)	8/20	-	-	9.9	0.20	0	0.13	200	66	3	8.4
		8/22	-	-	11.3	-	-	-	-	71	8	8.4

Table 3 - SUMMARY OF ANALYTICAL RESULTS ON RIVER WATER SAMPLES (Continued)

Sampling Range	Distance from North Shore	Date (1952)	Turbidity ppm	Temp. °C	D.O. ppm	NH_3 ppm	NO_2 ppm	PO_4 ppm	Spec. Cond. umhos per cm.	Alkalinity ppm		pH
										M.O.	Phen	
C-167 (Cont.)	3/4(30' Depth)	8/25	-	-	10.5	1.60	0	0.06	190	67	8	8.5
		8/27	-	-	10.7	0.80	0	0.05	170	70	6	8.4
C-163	1/4 (Surface)	8/22	15	19.5	11.2	-	-	-	-	72	5	8.4
	3/4 (23' Depth)	8/22	-	19.5	11.5	-	-	-	-	69	7	8.4
	1/2 (Surface)	8/22	15	19.5	11.6	-	-	-	-	71	6	8.4
	3/2 (45' Depth)	8/22	-	19.5	11.5		-	-	-	71	7	8.4
C-150	1/4 (Surface)	8/20	15	20.0	10.6	0.22	0	0.01	200	72	2	8.4
		8/25	-	19.5	9.8	0.34	0	0.06	190	68	7	8.4

Table 3 - SUMMARY OF ANALYTICAL RESULTS ON RIVER WATER SAMPLES (Continued)

Sampling Range	Distance from North Shore	Date (1952)	Turbidity ppm	Temp. °C	D.O. ppm	NH_3 ppm	NO_2 ppm	PO_4 ppm	Spec. Cond. mmhos per cm.	Alkalinity ppm		pH
										M.O.	Phen.	
0-150 (Cont.)	1/4 (Surface)	8/27	10	19.5	10.2	1.60	0	0.16	180	70	8	8.4
	1/4 (80' Depth)	8/20	-	20.0	10.2	0.28	0	0.01	200	73	2	8.3
		8/25	-	19.5	9.8	0.06	0	0.08	190	69	8	8.5
		8/27	-	19.5	10.0	0.48	0	0.01	180	69	7	8.4
	1/2 (Surface)	8/20	15	20.0	10.6	0.42	0	0.01	200	72	1	8.3
		8/25	14	19.5	9.9	0.18	0	0.03	190	68	7	8.5
		8/27	10	19.0	10.2	1.60	0	0.05	180	68	7	8.4
	1/2 (64' Depth)	8/20	-	20.0	10.6	0.48	0	0.01	200	70	0	8.3
		8/25	-	19.5	9.8	0.04	0	0.02	190	69	7	8.4
		8/27	-	19.0	10.2	0.48	0	0.04	180	69	8	8.4
	3/4 (Surface)	8/20	15	20.0	10.6	0.80	0	0.11	200	71	1	8.3
		8/25	17	19.5	9.9	0.08	0	0.06	190	69	6	8.4

Table 3 - SUMMARY OF ANALYTICAL RESULTS ON RIVER WATER SAMPLES (Continued)

Sampling Range	Distance from north Shore	Date (1956)	Turbidity ppm	Temp. °C	$D.O.$ ppm	NH_3 ppm	NO_2 ppm	PO_4 ppm	Spec. Cond. Mhos per cm.	Alkalinity ppm		pH
										M.O.	Phen.	
0-150 (Cont.)	3/4 (Surface)	8/27	13	19.5	10.2	0.00	0	0.02	180	68	7	8.4
	3/4 (30' Depth)	8/20	-	20.0	10.5	0.20	0	0.01	200	72	2	8.4
		8/25	-	19.5	9.6	0.14	0	0.04	190	69	6	8.4
		8/27	-	19.0	9.8	0.48	0	0.07	180	69	6	8.4

Table 4 - RESULTS OF MINERAL ANALYSES ON RIVER WATER SAMPLES
(Cross-Section Samples)

Sampling Range	Date (1952)	Ca	Mg	Fe	Mn	Zn	Cu	SO_4	NO_3	Total Solids
		Concentration - Parts per million								
C-193	8/20	20	5.3	0.55	0.03	0.003	0.006	15	0.00	110
	8/25	18	6.0	0.21	0.02	0.000	0.004	15	0.03	100
	8/27	19	6.4	0.19	0.02	0.005	0.005	16	0.01	130
C-167	8/20	20	5.2	0.10	0.03	0.004	0.004	15	0.00	100
	8/25	18	6.2	0.10	0.04	0.004	0.005	14	0.06	150
	8/27	19	6.6	0.19	0.02	0.000	0.004	16	0.01	120
C-150	8/20	20	5.5	0.55	0.03	0.000	0.004	14	0.07	100
	8/25	18	6.5	0.22	0.04	0.000	0.004	16	0.05	120
	8/27	19	6.0	0.15	0.03	0.000	0.005	16	0.20	120

Two samples indicated a fairly uniform distribution of plankton throughout the pool and little change in composition from surface to bottom. The weight of plankton appeared to depend more on the presence of silt than upon the number of organisms present. The average number of organisms in this area (2,500 - 4,500 per ml.) was considerably higher than had been found during a similar period in the upper Columbia River (Priest Rapids - Paterson Section), but not as high as had been found in some of the tributaries above Mallery Dam.

Diatoms were the predominant form, making up from 85 to 90% of the total number of plankters present. The remaining population consisted of from 10 to 15% single-celled green algae and 1 to 5% blue-green algal forms. The number of protozoans, while not abundant percentage wise as compared to the other organisms, were much more abundant than in the Priest Rapids - Paterson Section, averaging as high as 1,175 per 200 ml. in surface samples taken in the lower reservoir. There was evidently no build-up of the other zooplankton within the pool. A few rotifers were present at all ranges but microcrustaceans were extremely scarce.

Table 5 presents the various kinds of plankton organisms (in number per milliliter), as well as the wet weight and volume of organic matter (both in grams per liter).

From the figures given, there appears to be little or no build-up of plankton within the reservoir at this season of the year. The forms present were quite similar to those in other unimpounded portions of the river and occurred in the same relative proportions, with a possible slight increase in green and blue-green algae and protozoans. The increase in protozoans could probably be attributed to increased organic pollution

Table 5 - PLANKTON - COLUMBIA RIVER

SAMPLING DATA				Plankton Weight		PLANKTON COUNT - AVERAGE NUMBER OF ORGANISMS																												
						Per Milliliter																		Per 200 Milliliters										
Sampling Range	Mileage Index Number	Location of Sample (Cross-section)	Date of Sample	Wet Weight per Liter Milligrams	Organic Matter per Liter Milligrams	BACILLARIOPHYCEAE - TOTAL	Asterionella SP.	Stephanodiscus SP.	Diatoma SP.	Fragilaria SP.	Gomphonema SP.	Navicula SP.	Nitzschia SP.	Synedra SP.	CHLOROPHYCEAE - TOTAL	Ankistrodesmus SP.	Scenedesmus SP.	Pediastrum SP.	Actinastrum SP.	CYANOPHYCEAE - TOTAL	Oscillatoria SP.	FLAGELLATES - TOTAL	PROTOZOA - TOTAL	Euglypha SP.	FILAMENTOUS BACTERIA and FUNGI - TOTAL	CRUSTACEA - TOTAL	Copepods	ROTIFERA - TOTAL	ANNELIDA SP.	NEMATODA SP.	TOTAL ORGANISMS PER MILLILITER
Columbia River above The Dalles, Ore.	C-191	Surface	8/20	13.25	3.52	2,076	5	1,550	2	81	4	47	14	11	346	127	18	84	14	4	52		9	976	864	8			12		32	2,264
		Surface	8/25	2.13	0.51	4,629		4,087		153		44	54	15	237	848	198	310	10	20	99	5	25	242	214				4	2	2	5,561
		Depth		8.69	2.23	4,539	29	3,983		158	5	10	49	5	246	734	212	212	10	49	44		20	134	130	4			6	2	4	5,337
		Surface	8/27	3.92	1.16	4,215		3,599		158	5	39	20	10	315	642	44	266	10	25	10		49	335	322				10	10	6	4,916
Columbia River above Lyle, Wn.	C-182	Surface	8/24	9.17	2.64	6,098	15	4,974		281		69	49	15	655	661	35	311	29	10	64		20	248	224				2		6	6,843
		Depth		10.97	3.09	3,386		2,573		182		39	10	5	557	252	10	74	30		10		10	482	470				10	4	48	3,698
		Surface	8/27	8.50	1.94	5,547		4,743	15	140		99	64	5	478	503	39	227	10				20	530	514				4	2	4	6,070
Columbia River below White Salmon River	C-167	Surface	8/19	13.07	2.32	502	7	233		66		18	14	16	129	95	23	52	7	2	20		7	66	54				8	8	12	624
		Depth		6.03	1.21	2,738	18	1,483	9	307	18	99	36	63	624	316	18	226	45		63		45	96	96				16			3,162
		Surface	8/22	8.75	1.97	2,687	20	1,715	5	118	5	10	20	10	739	203	5	64	20	20	103		25	101	100						12	3,018
		Depth		12.46	2.25	3,726	39	2,652	39	118	10	39	39	10	730	454	20	256	20	20	128		20	144	44				12		12	4,328
		Surface	8/25	6.15	1.52	3,737	20	2,741		222	5	44	15	10	631	425		242	25	5	20		35	1,172	1,158				8	4	44	4,217
		Depth		11.42	2.36	4,644	20	3,441	10	286	10	89	49	10	651	630	99	296	49		79		39	176	144		4	4	12	4	36	5,392
		Surface	8/27	11.76	2.22	4,891	20	4,363	5	118		39	35	10	201	435	15	197	10	20	10		39	160	124				8	6	26	5,375
		Depth		17.40	3.46	5,295	20	4,516		128	10	69	30	39	414	523	30	256	20		10		30	272	232				4		32	5,858
Columbia River above Wn. White Salmon River	C-163	Surface	8/22	9.47	1.87	3,135	29	2,445		113		5	10	5	444	375	49	143	5	99	192			114	102				6		2	3,702
		Depth		15.73	2.51	3,497	54	2,450	5	99	5	25	25	15	799	391	20	168	35	15	64			112	106				18	4	2	3,991
Columbia River below Stevenson, Wn.	C-150	Surface	8/20	13.32	1.87	1,678	5	1,366		25		10	25		247	238	5	94	20	10	15		44	372	368				8	8	1	1,975
		Depth		14.63	2.32	1,953	5	1,400		49	15	39	10	30	380	209	5	89	10				64	148	144				10	4		2,225
		Surface	8/25	5.13	1.18	2,328	25	1,523		143	15	10			582	386	20	173	15	20	49		20	1,872	1,638		2	2	8	6	26	2,783
		Depth		9.46	1.93	2,224	5	1,689		182		25	20	15	473	301	10	138	30	10	30		5	998	966				8	6	36	2,560
		Surface	8/27	5.78	1.42	2,770	5	2,095		247		30	15	25	330	445	25	227	20	20	25		15	1,280	1,258				8	2	30	3,257
		Depth		12.29	2.16	2,253	5	1,883		118		20	15	5	182	337	5	89	15	20	39		30	56	34				14	8	28	2,629

downstream, rather than to the effects of the impoundment.

As the seasonal variation in plankton is generally large, studies at other seasons of the year would be advisable to determine if the reservoir had any effects on these organisms. An examination at extreme low water conditions, generally occurring just before the spring flood, would probably give the best indication of any possible effect of the reservoir on plankton.

Bottom Organisms

The numbers and weights of bottom animals in the quantitative collections made at the various ranges are shown in table 6. From the limited number of samples taken, bottom conditions appeared very poor and entirely different from those found in unimpounded areas of the Columbia River. The predominating animals at all ranges were oligochaete worms and midgefly larvae. The only other organisms found were a few snails and clams and an occasional amphipod. Only one mayfly nymph and no caddisfly larvae were found in any of the samples. The contrast between this area and the unimpounded Priest Rapids - Paterson area was striking, as mayfly nymphs and caddisfly larvae were among the most predominant forms found in the upstream section.

The samples, while indicating the conditions on the major portion of the pool bottom, did not take into account the most productive areas within the reservoir. Such locations, very limited in extent, lie along the immediate shoreline and at the shallow gravelly points jutting out into the pool. A few of the areas examined showed mayfly nymphs, damselfly nymphs and caddisfly larvae to be reasonably abundant. A large number of amphipods (Corophium sp) were also found. Quite a few snails and an occasional crayfish

Table 6 - BOTTOM FAUNA - COLUMBIA RIVER

SAMPLING DATA						ORGANISMS								
Sampling Range	Mileage Index Number	Distance from North Shore	Number of Samples @ Depth Taken	Date of Sample (1952)	Size of Sample and Method of Collection		Oligochaetes (Aquatic Earthworms)	Amphipods (Scuds)	Ephemerids (Mayfly nymphs)	Diptera: Chironomidae (Midgefly larvae)	Mollusca: Gastropoda (Snails)	Lamellibranchiae (Clams)	TOTAL	TOTAL PER SQUARE FOOT
Columbia River above Lyle, Wn.	C-182	1/4 1/2 3/4	2 @ 55' 2 @ 34' 2 @ 15'	8/24	1.5 Sq.Ft. Ekman	Number	36			7			43	29
						Weight	0.04			0.02			0.06	.04
Columbia River Below White Salmon River	C-167	3/4	2 @ 30'	8/22	0.5 Sq.Ft. Ekman	Number	151		1	51	2		205	410
						Weight	0.17			0.07			0.24	.48
		1/4	2 @ 90'		"	Number	141			11	1		153	306
						Weight	0.11			0.01	0.11		0.23	.46
		1/2	2 @ 60'		"	Number	7			5			12	24
						Weight	0.01			0.01			0.02	.04
		1/2	4 @ 70'	8/25	1.0 Sq.Ft. Ekman	Number	6	1		36			43	43
						Weight				0.03			0.03	.03
		3/4	4 @ 14'		"	Number	115	4		29	1		149	149
						Weight	0.11			0.07			0.18	.18
		1/4 1/2	2 @ 80' 2 @ 54'	8/27	"	Number	47			66		1	114	114
						Weight	0.03			0.10			0.13	.13
Columbia River above Little White Salmon River	C-163	1/4	1 @ 23'	8/22	0.25 Sq.Ft.	Number	43			10	13		66	264
						Weight	0.03						0.03	.12
		1/2	1 @ 45'		"	Number	3			7	1	1	12	48
						Weight				0.01			0.01	.04
Columbia River below Stevenson, Wn.	C-150	1/4 3/4	1 @ 31' 3 @ 21'	8/25	1.0 Sq.Ft. Ekman	Number	125			54			179	179
						Weight	0.09			0.07			0.16	.16
		1/2 3/4	2 @ 64' 2 @ 30'	8/27	"	Number	98			39	14		151	151
						Weight	0.06			0.04	1.62		1.72	1.72

were also present. Other fairly productive locations were observed at a few shallow areas where rooted vegetation had become established. The very steep drop-off of the river banks on the Washington side and the quite sandy nature of the Oregon shore limited the extent of the more productive areas.

The physical nature of most of the pool bottom was such as to discourage the establishment of bottom animals. In general, the river bed appeared to be covered with a layer of fairly coarse to fine sand, and debris consisting principally of sawdust, bark and wood fibers. This condition appeared general throughout the lower half of the pool, except in shallow shore-line sections which were kept fairly clean by wave action. Some mud deposits were observed in shore areas. It is highly probable that the sand deposits are laid down during the annual spring run-off periods. The increased sediment load present at that time is partially deposited as the river velocity is decreased in passing through the reservoir. These deposits may have a smothering effect on bottom animals. The extensive lumber operations in this area and the use of the pool in these operations would account for the large amount of debris found in the samples.

Juvenile fish collections were quite limited in extent, being made only one to three times at each sampling range and all taken near the Washington shore. The following species were found in the various collections:

Bass, largemouth	- Micropterus salmoides
Carp	- Cyprinus carpio
Chiselmouth	- Acrocheilus alutaceus
Crappie, white	- Pomoxis annularis
Dace, speckled	- Apocope oscula

Sculpin, rough	- Cottus sp
Shad, white	- Alosa sapidissima
Shiner, Columbia River	- Richardsonius balteatus
Squawfish, Oregon	- Ptychocheilus oregonensis
Sturgeon, white	- Acipenser transmontanus
Sucker, coarse-scaled	- Catostomus macrocheilus

There are no doubt many other species of fish within the pool, but these were the only ones found during this survey. Juvenile salmon are probably abundant during certain seasons of the year but would not be expected during the period this study was made. Shiners, squawfish and chiselmouth were in much greater abundance in the collections than were any other species. They were fairly numerous at all ranges within the pool but much less abundant, or at least much more difficult to collect, than in the Priest Rapids - Paterson section. The presence of bass and crappy young-of-the-year indicate at least some successful spawning of spiny-rayed species within the pool area. A few shad juveriles collected near Stevenson, Range C-150, indicate some spawning of this anadromous species above Bonneville Dam.

Due to rough water and lack of time very little gill netting was done. One bottom-set, with a 125 yard, 1", 2" and 3" mesh, was made at Range C-167. One hundred and twenty sturgeon, ranging from 15 to 40 inches and 1/2 to 7-1/2 pounds, were taken in this overnight set. The only other fish taken at the same time was one fairly large squawfish. Other adult fish observed or taken by fishermen within the pool during this survey were numerous squawfish, some carp, a fair number of large steelhead (Salmo gairdneri), ranging up to 25 pounds in weight, and several chinook salmon (Oncorhynchus tshawytscha), ranging up to 35 pounds. A few other species were observed in the fish ladders

at Bonneville Dam, including lampreys (Lampetra sp) and white shad. Large numbers of salmon, (mostly chinook, but a few of other species) and steelhead were passing over the fish ladders during this period.

There is some commercial fishing within Bonneville pool during seasons set by the State fisheries departments of Washington and Oregon. Most of this is for blueback (Oncorhynchus nerka) and chinook (Oncorhynchus tshawytscha) salmon and is done with drift gill nets. There is also a limited amount of commercial fishing for sturgeon. Headquarters for most of these operations are in the Drano Lake, Underwood, Hood River and The Dalles areas. Fish trucks from the Astoria canneries pick up the catches at regular intervals during the season.

Excellent sport fishing is available seasonally in a few areas within the pool. Most of it is for steelhead trout and confined mainly to locations near the mouths of tributary streams. Among the best of these areas are the mouth of the White Salmon River, Drano Lake and the mouth of the Wind River. Extensive sport fishing was observed at the mouth of White Salmon River and in Drano Lake. Numerous steelhead trout, weighing from 5 to 25 pounds were taken by fishermen, along with an occasional large chinook salmon. Most of this fishing was by trolling and casting using artificial lures, mostly spoons of some kind. It is reported that good steelhead fishing is available in some of the tributaries; in the White Salmon River up to the power dam, approximately 2 miles above the mouth; in the Wind River to Shepherd Falls; and in the Klickitat River, within the lower 25 miles. Fishing for resident trout is also carried on.

Sport fishing for sturgeon is quite extensive within the Bonneville pool. Most of it is done from the bank, usually using pounds and is

some form of salted salmon. It is reported that quite a few are caught throughout the year. A large number of squawfish are taken by sturgeon fishermen but are considered as pests and not utilized to any extent. There is a small amount of fishing for bass and other spiny-rayed species in a few back-water areas.

The very rough water frequently existing, and caused by westerly winds through the Cascade Gorge, precludes wide use of small boats for fishing and recreation. There are only a very few periods during the year when such craft can be taken out safely. Otherwise the pool would probably be used more extensively both for fishing and boating.

Biologically, the major change occurring within the impoundment appears to be the definite change in bottom fauna. The pool areas appear much less productive in this respect than similar areas in unimpounded sections of the river. The organisms present are also of a less desirable form from a fish food standpoint. This would probably have little or no effect on populations of anadromous species of fish, since the adults are not feeding while in this area and the juveniles are present for only a short period of time. It would, however, probably tend to discourage an increase in certain resident species. The physical condition of the pool, with the very steep shores, quite sandy areas, and large amounts of woody debris on the bottom, would also tend to discourage resident fish populations. Plankton conditions do not appear to appreciably change within the impoundment.

The U. S. Fish and Wildlife Service is carrying out extensive hatching operations and a rehabilitation program for salmon in this area. This seems to be proving quite successful. The sturgeon population appears to be fairly well stabilized. It might perhaps be possible to increase fishing for spiny-rayed species in certain of the back-water areas and pools separated

from the main reservoir by railroad and highway fills. Reducing the release of sawdust and wood fibers from the many sawmills in the area would improve conditions for all kinds of fish and all other aquatic organisms. The abundant squawfish creates a predator problem for young salmon, but probably no more serious in this area than in other sections of the Columbia River. No methods are known at present to discourage this species.

RADIOLOGICAL EXAMINATIONS

The source of the radioactivity found in the Bonneville Reservoir, for other than background levels, is the Hanford Works of the Atomic Energy Commission located over 150 miles above the upper end of the impoundment. Any such radioactivity detected in the Bonneville area would be due to relatively long-lived isotopes. The flow time between the Hanford Works and the upper end of the reservoir is in the neighborhood of 60 to 70 hours. The radioactivity then is probably due principally to P^{32}, which has a half-life of 14.3 days.

Water

The results of the gross beta activity densities for water samples are presented in table 7.

The results indicate a uniform mixing of the radioactive elements across the entire reservoir and a gradual decrease of activity from an average of 27×10^{-8} µc/ml. near The Dalles, to 14×10^{-8} µc/ml. near the center and 9×10^{-8} µc/ml. at the lower end of the pool. There was good agreement in the 3 sets of samples collected at each range.

These values are as expected, in the light of the flow time, natural dilution, and radiological results at Hanford and Paterson. The half-life of this activity was about 2 to 3 days during the first 6 days after sample

Table 7 - RESULTS OF RADIOACTIVITY COUNTING - WATER

Distance from North Shore	Date (1952)	Gross Beta Activity Density - 10^{-8} μc/ml.		
		Range 0-191	Range 0-167	Range 0-150
1/4 (Surface)	8/20	22	12	8
	8/25	27	15	9
	8/27	32	18	11
1/2 (Surface)	8/20	22	12	7
	8/25	29	14	10
	8/27	32	16	10
3/4 (Surface)	8/20	23	8	9
	8/25	26	13	9
	8/27	29	15	12

collection. It was difficult to get a good decay curve because of the delay of over 24 hours before making the initial count.

Aquatic Organisms

The results for gross beta activity density of plankton, algae, snails, and juvenile fish are shown in table 8. Values for individual parts of adult fish are shown in table 9.

Appreciable amounts of radioactivity were found in all the types of aquatic organisms examined throughout the pool. There was no significant difference in these values at the various ranges. The variation in individual samples at the same range was equal to or greater than that between ranges.

Results for plankton and algae were considerably less than those found in the Columbia River at Paterson (approximately 90 miles upstream from the head of the reservoir) but values for juvenile fish and some other aquatic animals were in the same order of magnitude as those found upstream.

The pattern for radioactivity densities found in the Bonneville Pool

Table 8 - RESULTS OF RADIOACTIVITY COUNTING - ALGAE, PLANKTON, BOTTOM FAUNA, AND JUVENILE FISH

SAMPLING DATA				GROSS BETA ACTIVITY DENSITY IN 10^{-7} μc/gm.												
Sampling Range	Mileage Index Number	Location of Sample	Date of Sample (1952)	Algae	Plankton	Snails Gastropods - entire	Crayfish Astacus klamathensis	Bass, Largemouth Micropterus dolomieu	Carp Cyprinus carpio	Chiselmouth Acrocheilus alutaceus	Crappie, White Pomoxis annularis	Dace, spotted Agosia nubila	Sculpin, Rough Cottus sp.	Shiner, Columbia River Richardsonius balteatus	Squawfish Ptychocheilus oregonensis	Sucker, Coarse scaled Catostomus macrocheilus
Columbia River above The Dalles, Oregon.	C-191	Cross-section	8/20		2,400 1,900											
		North-shore	8/25	74 62	2,600* 3,100*					1,200 1,200 2,400				2,900 3,000 2,500	1,400 1,800 3,300	3,200 4,500 4,300
		Cross section	8/27		5,200 5,100											
Columbia River above Lyle, Wn.	C-182	North shore	8/24	48 40	4,800* 4,100*					670				1,200 660 1,500	850 1,700 1,100	
Columbia River below White Salmon River	C-167	North shore	8/19		11,000* 13,000*											
			8/21	520 550			1,000			1,100				2,200 2,500 3,400	1,300 690 2,500	
		Cross-section	8/22		4,000 3,900											
			8/25		5,200 4,700											
			8/27		4,400 4,400											
Columbia River above Little White Salmon River	C-163	Cross-section	8/22		6,600 4,900											
		North shore	8/26	410 430		270 280		4,900 4,200	2,100 1,200			4,400 5,300	1,600 2,700	580 2,800 4,000	3,600 4,000 2,800	3,800 2,300 2,400
Columbia River at Collins, Wn.	C-158	North shore	8/21	260 300		280 440 940				1,200 1,100 1,400				970 800 890		
Columbia River below Stevenson,	C-150	Cross-section	8/19	270 180						1,200 1,300	2,600 3,000		2,700			
			8/20		13,000 13,000											
		North shore	8/25	130	5,000* 4,600*					1,000				840 1,400 2,100	930 1,900 1,300	1,700
		Cross-section	8/27		5,300 4,300											

(*) Represents Cross-sectional sample.

Table 9 - RESULTS OF RADIOACTIVITY COUNTING - FISH, ADULT (INDIVIDUAL PARTS)

SAMPLING DATA								GROSS BETA ACTIVITY DENSITY IN 10^{-7} μc/gm.								
Sampling Range	Mileage Index Number	Location of Sample	Date of Sample (1952)	Kind of Fish	Length of Fish (Millimeters)	Weight of Fish (Grams)	Sex and Condition (*)	Scales	Muscle	Liver	Bone	Ovary	Testes	Kidney	Stomach and Intestional Contents	Skin
Columbia River	C-167	North Shore	8/23	Squawfish Ptychocheilus oregonensis	370	545	F-Ud.	79	51	150	100	75	-	81	350	6
				" "	270	265	M-Ud.	85	49	200	75	-	-	90	1,000	3
			8/28	" "	430	800	F-Ud.	85	34	510	96	49	-	170	-	15
			8/28	Sturgeon Acipenser transmontanus	1,000	3,400	F-Ud.	16	2	150	3	56	-	42	1,000	28
				" "	690	1,800	F-Ud.	180	24	140	100	-	-	210	580	140
				" "	560	1,200	F-Ud.	91	60	260	64	80	-	280	2,200	160
				" "	480	560	M-Ud.	550	89	910	99	-	340	790	1,600	300
				" "	410	370	F-Ud.	1,700	74	630	110	410	-	720	1,500	380
				" "	380	280	F-Ud.	1,100	95	570	160	190	-	600	1,800	360
				" "	380	260	M-Ud.	1,100	130	660	220	-	130	660	2,200	640

(*) F = Female; M = Male; Ud. = Undeveloped.

was somewhat similar to that established in the Priest Rapids - Paterson Section of the Columbia River. The magnitude of the differences between types of organisms, however, was much less. In the upstream section activity values for plankton and algae, which took nutrients directly from the water, were highest. Next in order were bottom animals and then fish. The latter accumulate activity only through feeding.

Values for plankton, which were ten times higher than for juvenile fish in upstream sections, were only slightly higher for plankton (1.9 to 13 x 10^{-4} μc/gm) than for fish (0.58 to 5.2 x 10^{-4} μc/gm) in the reservoir.

The probable reason for the relatively small difference is that most of the short-lived activity has disappeared by the time the water reaches this area and the activity present in both plankton and fish is due to longer-lived isotopes such as P^{32}. Upstream, on the other hand, a large part of the activity in plankton is due to short-lived isotopes absorbed directly from the water. Very low values (0.04 to 0.55 x 10^{-4} μc/gm.) obtained for algae from the Bonneville pool were probably due to the samples being taken in shore areas away from the main channel. Water activity values were also lowest in the shore areas.

All species of juvenile fish appeared to concentrate radioactivity in somewhat similar amounts. Highest values were found in suckers and dace but individuals of other species were found to contain nearly equal amounts. Only two species of adult fish were examined. Values for sturgeon were generally higher than those for squawfish. Stomach contents contained the most activity, ranging up to 2.2 x 10^{-4} μc/gm., with muscle giving the lowest result, a maximum of 0.13 x 10^{-4} μc/gm.

From studies of radioactivity in the Priest Rapids - Paterson section, it is expected that radioactivity in aquatic organisms in the Bonneville area during the period of this study were not quite at maximum levels. Values possibly twice as great may be expected a month or two later. Radioactivity levels found in aquatic organisms in Bonneville Reservoir, while significantly above natural background, would be expected to have little or no effect on aquatic organisms or the use of these organisms.

Bottom Muds

The radioactivity results for the limited number of bottom mud samples are given in table 10.

Table 10 - RESULTS OF RADIOACTIVITY COUNTING - BOTTOM MUDS

Sampling Range	Distance from North shore	Date (1952)	Activity Density - 10^{-7} μc/gm.	
			Gross Beta	Alpha
C-191	3/4	8/25	160	-
		8/27	216	4.7
C-167	1/2	8/20	65	3.3
	3/4	8/20	45	1.8
		8/25	77	2.3
		8/27	130	5.3
C-150	1/2	8/20	13	2.3
		8/25	37	5.9
		8/27	78	4.7

The half-life of the samples, as determined from gross beta decay studies was about 40 days, indicating that the activity may be due to an isotope similar to Fe^{59}, which has a half-life of 46.5 days. The alpha activity levels were low, but definitely above minimum detectable limits.